

What is claimed is:

1. A method of detecting an opaque image in an area of each of a sequence of frames comprising pixels that represent digital video images, comprising the steps of:

5 detecting a scene change between at least two of said frames, designated as a current frame and a reference frame;

 upon detecting a scene change, calculating a stochastic measure σ_d of a plurality of pixels in the image frame based on the standard deviation of differences in
10 pixel values in said two frames in the temporal domain; and

 detecting an opaque image in said area by comparing the stochastic measure σ_d with a given noise level (STD).

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2. The method of claim 1, wherein the steps of detecting a scene change further includes the steps of:

 determining differences in pixel intensities between said two frames;

20 subtracting the noise mean from said differences;

 comparing the absolute values of the differences with noise mean subtracted to a first threshold value to detect pixels with significant intensity changes; and

comparing a percentage of a plurality of changed pixels in the current frame to a second threshold value to detect a scene change.

5 3. The method of claim 2, wherein the steps of determining differences in pixel intensities further include the steps of determining absolute difference in pixel intensities between said two frames.

10 4. The method of claim 2, wherein the first threshold value t_1 is a function of noise in the video images.

 5. The method of claim 4, wherein the first
15 threshold value t_1 is determined as $t_1 = a \times n + b$ such that n denotes the noise level, and a and b are adjustable parameters wherein increasing the values of a and/or b results in lower scene change detection sensitivity.

20 6. The method of claim 1, wherein the steps of detecting a scene change further includes the steps of:
 generating a count C of the number pixels in the current frame whose difference in intensity relative to corresponding pixels in the reference frame, after

subtracting the given noise mean, exceeds the threshold value .

7. The method of claim 1, wherein the steps of
5 detecting a scene change further includes the steps of, for each of a plurality of pixels in the current frame and each corresponding pixel in the reference frame:

determining the difference in pixel intensity between said two pixels;

10 subtracting the noise mean from said difference;
comparing the absolute value of the difference, from which the noise mean has been subtracted, to a first threshold value; and

incrementing a running count C if the difference
15 exceeds the first threshold value.

8. The method of claim 6, wherein the steps of detecting a scene change further includes the steps of:

determining a value p as a function of the ratio
20 of said count C and the total number N of pixels in each frame; and

comparing the value p to a second threshold value to detect scene change.

9. The method of claim 1 wherein the steps of calculating the stochastic measurement σ_d further includes the steps of:

generating the squared differences obtained for
 5 each of a plurality of said pixels;
 subtracting the noise mean from each difference;
 generating the sum of the absolute values of said
 difference with noise mean subtracted; and
 generating an average of the sums, and
 10 determining the stochastic measure σ_d based on said
 average.

10. The method of claim 9, wherein the stochastic measurement σ_d is determined as:

$$15 \quad \sigma_d = \sqrt{\frac{\sum_{t=1}^M |d(t) - \mu_s|^2}{M}}$$

wherein:

$$d(t) = p(t) - p(t - \tau),$$

M is the number of frames involved in scene
 20 change detection,

$p(t)$ denotes the pixel intensity value in one of
 said M frames, and

$p(t-\tau)$ denotes the corresponding pixel intensity value in another said M frames.

11. The method of claim 1, wherein the step of
 5 detecting an opaque image further includes the steps of:
 classifying each pixel in said area of the
 current frame as an opaque image pixel, if the σ_d for that
 pixel matches the given noise level, represented by the
 standard deviation σ_s .

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12. The method of claim 11, wherein the step of
 detecting an opaque image further includes the steps of:
 classifying a pixel $p(i)$ in the current frame as
 an opaque image pixel, if

15 $|\sigma_d(i) - \sigma_s| < t$, otherwise, classifying the pixel
 $p(i)$ as a non-opaque image pixel,

wherein,

$p(i)$ is the i^{th} pixel in the current frame,

σ_s is standard deviation of noise in the

20 video Signal, and

t is a pre-defined threshold for tolerating
 measurement and computation errors.

13. The method of claim 11, further comprising the steps of:

detecting and reclassifying any mis-classified pixels in a refinement process.

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14. The method of claim 13, wherein the refinement process further includes the steps of:

if a pixel is classified as a an opaque image pixel, while less than two of its neighboring pixels are
10 classified as opaque image pixels, then reclassifying that pixel as a non-opaque image pixel; and

if a pixel is classified as a non-opaque image pixel, while more than two of its neighboring pixels are
classified as opaque image pixels, then reclassifying that
15 pixel as an opaque image pixel.

15. An opaque image detection system for detecting an opaque image in an area of each of a sequence of frames including pixels that represent digital video images,
20 comprising:

a scene change detector that detects scene change between at least two of said frames, designated as a current frame and a reference frame;

a stochastic characteristic generator that upon
detection of scene change by the scene change detector,
calculates a stochastic measure σ_d of said area based on the
standard deviation of differences in pixel values in said
5 two frames in the temporal domain; and

an opaque image detector that detects an opaque
image in said area by comparing the stochastic measure σ_d
with a given noise level, represented by the standard
deviation σ_s .

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16. The system of claim 15, wherein the scene change
detector further determines differences in pixel
intensities between said two frames, and compares the
differences to a first threshold value to detect
15 significantly changed pixels, and compares the percentage
of significantly changed pixels within the current frame to
a second threshold to detect a scene change.

17. The system of claim 16, wherein the scene change
20 detector determines differences in pixel intensities by
determining absolute difference in pixel intensities
between said two frames.

18. The system of claim 16, wherein the first threshold value t_1 is a function of noise in the video images.

5 19. The system of claim 19, wherein the first threshold value t_1 is determined as $t_1 = a \times n + b$ such that n denotes the noise level, and a and b are adjustable parameters wherein increasing the values of a and/or b results in lower scene change detection sensitivity.

10 20. The system of claim 16, wherein the scene change detector further generates a count C of the number pixels in the current frame whose differences in intensities relative to corresponding pixels in the reference frame, with noise mean subtracted, exceeds the first threshold value.

15 21. The system of claim 16, wherein the scene change detector is further configured such that, for each of a plurality of pixels in the current frame and each
20 corresponding pixel in the reference frame the scene change detector determines the difference in pixel intensity between said two pixels with noise mean subtracted, compares the difference to the first threshold value, and

increments a running count C if the difference exceeds the first threshold value.

22. The system of claim 21, wherein the scene change
 5 detector further determines a value p as a function of the ratio of said count C and the total number N of pixels in each frame, and compares the value p to a second threshold value to detect scene change.

10 23. The system of claim 15, wherein the stochastic characteristic generator further calculates the stochastic measurement σ_d by generating a sum of the squared differences, with noise mean subtracted, obtained for each of a plurality of said pixels, generating an average of the
 15 sums, and determining the stochastic measure σ_d based on said average.

24. The system of claim 23, wherein the stochastic measurement σ_d is determined as:

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$$\sigma_d = \sqrt{\frac{\sum_{t=1}^M |d(t) - \mu_s|^2}{M}}$$

wherein:

$$d(t) = p(t) - p(t - \tau),$$

M is the number of frames involved in scene change detection,

$p(t)$ denotes the pixel intensity value in one of said M frames, and

$p(t - \tau)$ denotes the corresponding pixel intensity value in another said M frames.

25. The system of claim15, wherein the opaque image detector further classifies each pixel in said area of the current frame as an opaque image pixel, if the σ_d for that pixel matches a given noise level, represented by the standard deviation σ_s .

26. The system of claim25, wherein the opaque image detector further classifies a pixel $p(i)$ in the current frame as an opaque image pixel, if $|\sigma_d(i) - \sigma_s| < t$, otherwise, the opaque image detector classifies the pixel $p(i)$ as a non-opaque image pixel, wherein:

$p(i)$ is the i^{th} pixel in the current frame, and σ_s is standard deviation of noise in the video Signal, and

t is a pre-defined threshold for tolerating measurement and computation errors.

27. The system of claim 26, further comprising a
5 refinement module that detects and reclassifies any mis-
classified pixels in a refinement process.

28. The system of claim 27, wherein the refinement
module is further configured such that if a pixel is
10 classified as a an opaque image pixel, while less than two
of its neighboring pixels are classified as opaque image
pixels, then the refinement module reclassifies that pixel
as a non-opaque image pixel, and if a pixel is classified
as a non-opaque image pixel, while more than two of its
15 neighboring pixels are classified as opaque image pixels,
then the refinement module reclassifies that pixel as an
opaque image pixel.